



# TES Cloud Comparisons: MODIS

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# Outline

- TES approach to clouds
- Statistics compared with MODIS
- Comments on improvements in v002
- Conclusions





# COMPARISON TO FORMER APPROACHES

**Other instruments retrieve atmospheric parameters with clouds.**

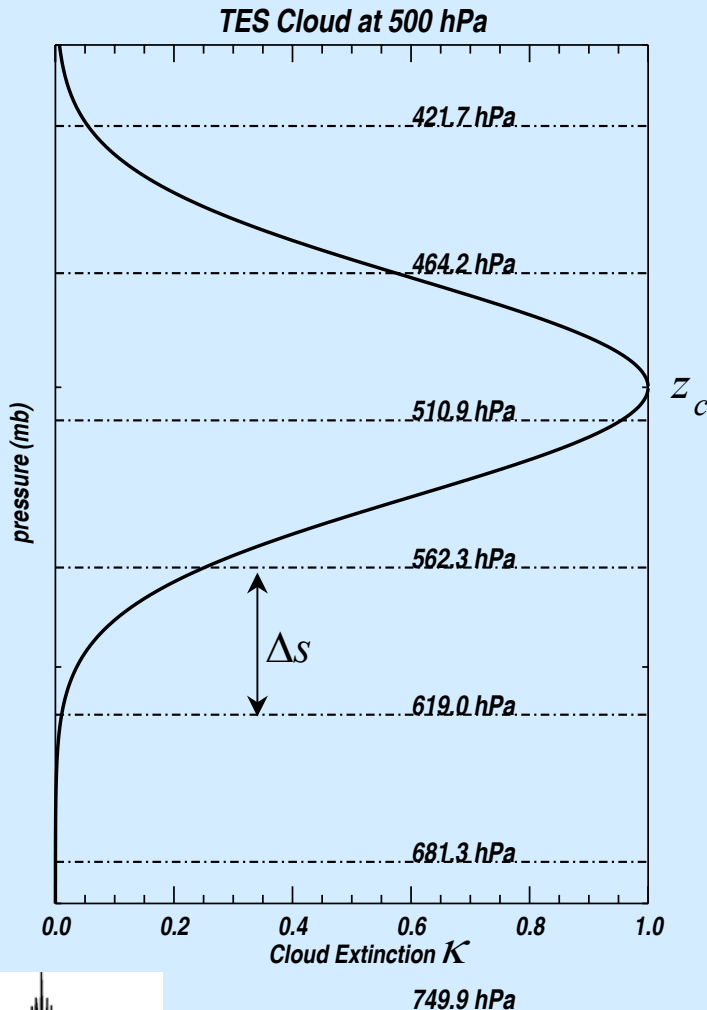
AIRS, TOMS, OMI, MOPITT successfully retrieve in the presence of clouds

**TES's approach is somewhat different than prior approaches**

- 1) Parameterize clouds and place the effect of these parameters into our forward model
- 2) Retrieve cloud parameters like any other retrieved parameter, with an initial guess, *a priori*, constraint, and Jacobians
- 3) Error characterization *and effect of clouds on retrieved atmospheric species* is handled like any other retrieved parameter



# TES CLOUD PARAMETERIZATION



- Single cloud layer modeled as a Gaussian profile
- Absorption and scattering modeled with an effective tau discretized on a coarse frequency grid 25 – 100  $\text{cm}^{-1}$

$$\tau_{\nu,z} = \kappa_{\nu} e^{-\beta(z-z_c)^2} \Delta s$$

*Effective extinction (25 frequency values)*

*Altitude*

*width parameter (fixed)*

*layer thickness*

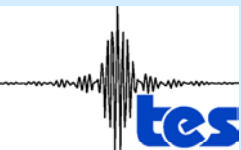
Initial guess: cloud pressure = 500 mb. Cloud extinction by Brightness temperatures between observed radiance and TES cloud-free initial guess





# The data sets

- TES
  - Step and stares as well as global surveys
  - Data averaged over 16 pixels to 5km by 8km
  - Some screening based on ctp error ( $< 100\text{mb}$ ) and effective optical depth (error  $< 2 \cdot \text{od}$ ) in later analysis
- MODIS data
  - Cloud top pressure - 5km product day and night
  - Cloud optical depth - 1km product, daytime only
  - Only use confidently cloudy data (cloud mask = 0)



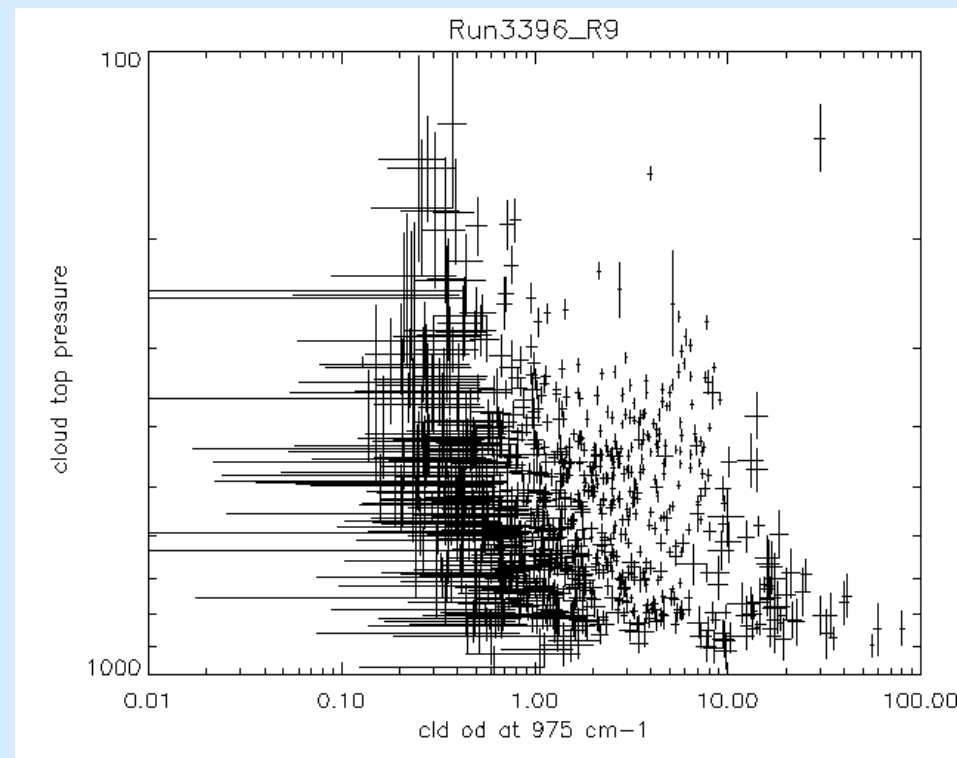
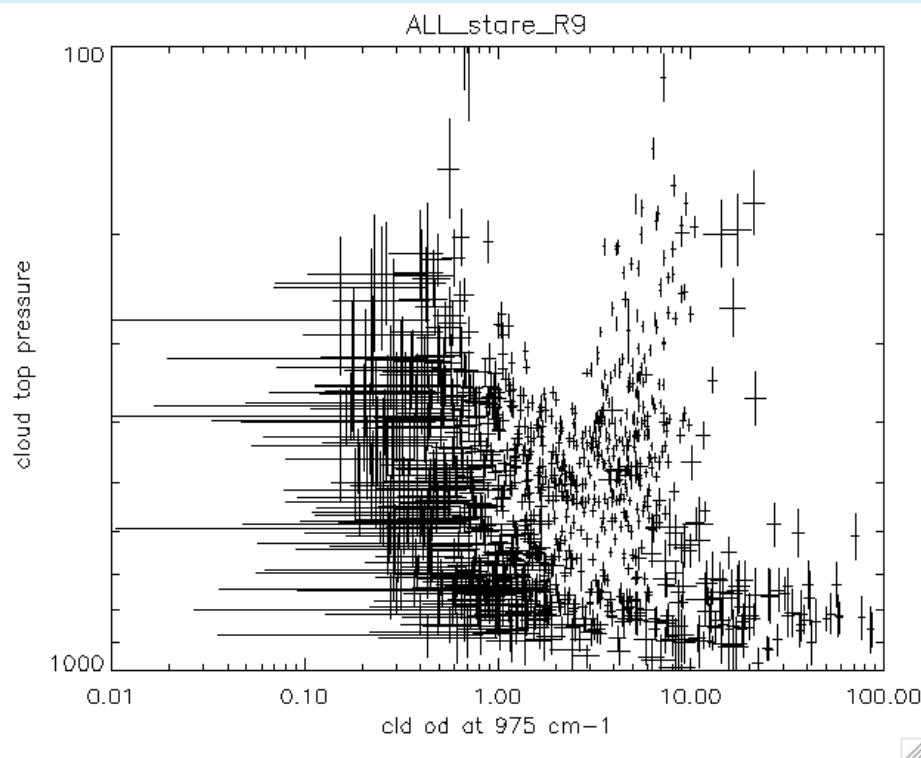


# Analysis approach

- Scattergrams and statistics on optical depth and cloud top pressure
- Interpretation in context of cloud homogeneity and error estimates



# TES characteristics

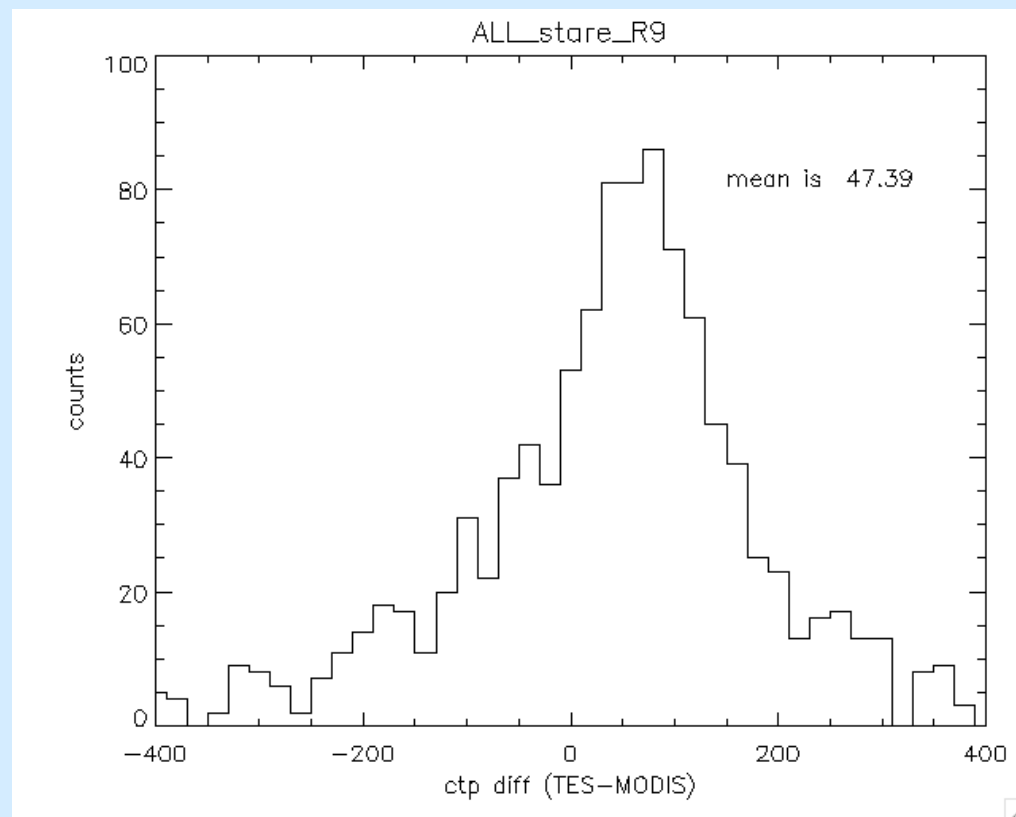


- Low optical depth data have larger errors
- Thick near surface clouds uncertain



# Cloud Top Pressure

- Histogram of TES-MODIS
- Majority of TES CTP are within -50 to +150 mb of MODIS. TES bias to larger pressures in part due to Gaussian cloud.

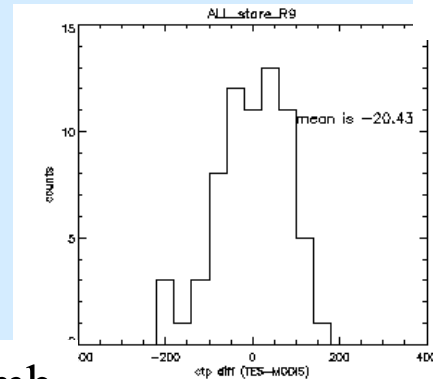




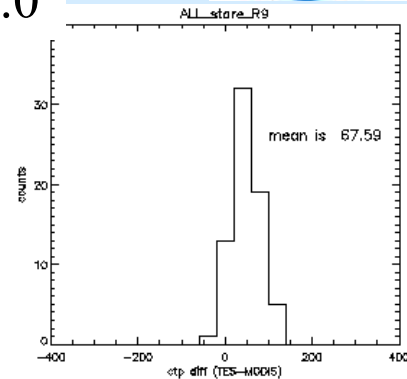
# Details of CTP

- Six groups of data
- Low and middle clouds with lower OD have outliers
- Thicker clouds consistently show TES CTP > MODIS by 100mb

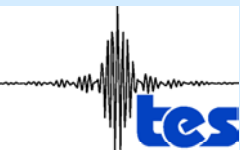
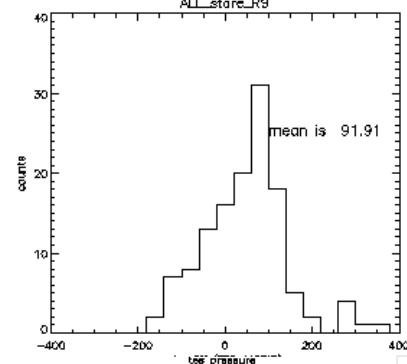
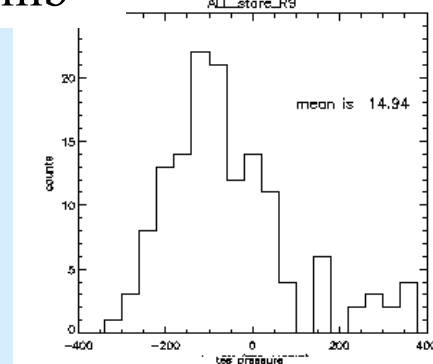
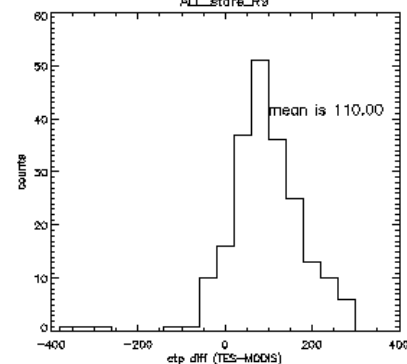
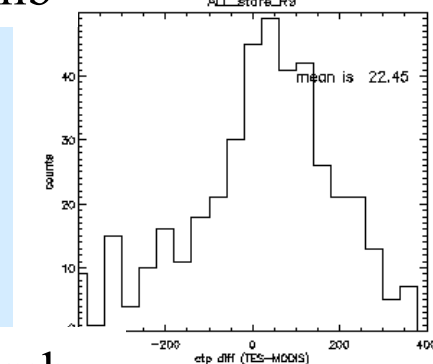
350mb



3.0

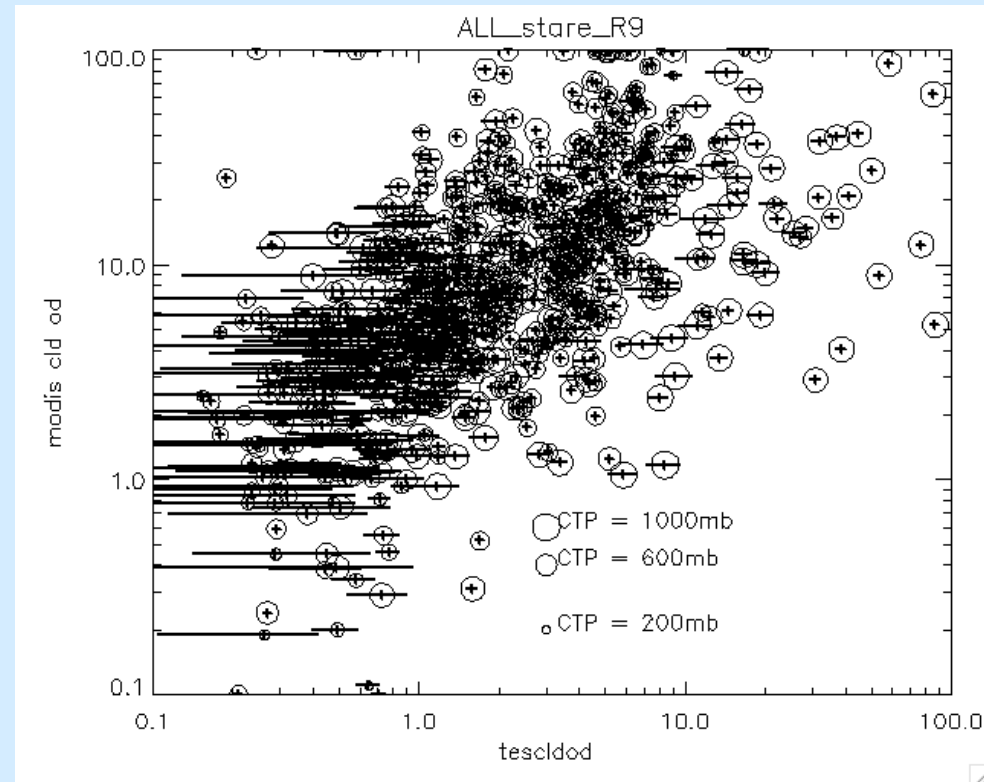


700mb

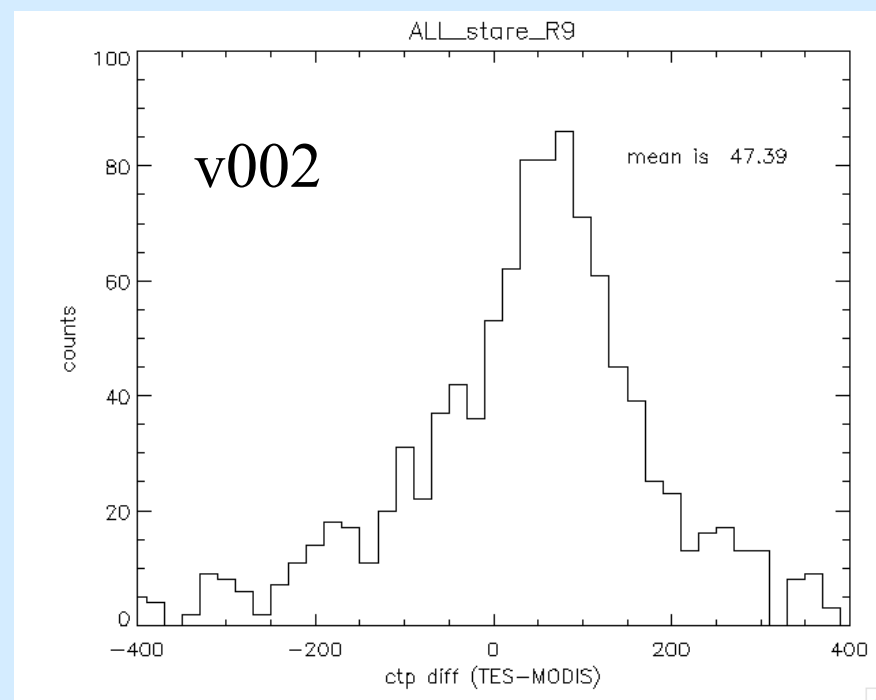
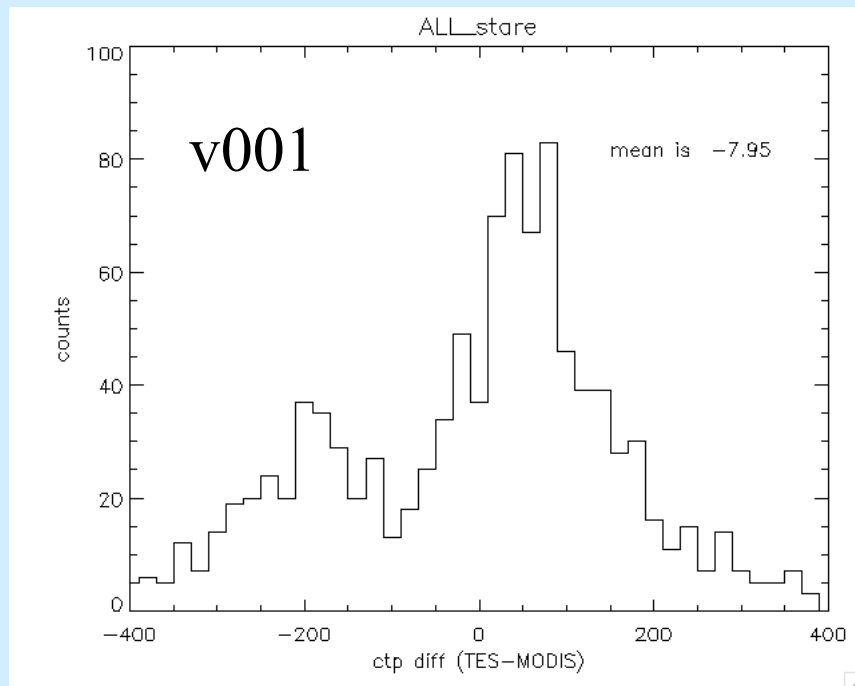


# Optical depth comparison

- MODIS and TES see fundamentally different optical depth
- Expect  $\sim 2$  scaling, depending on cloud type



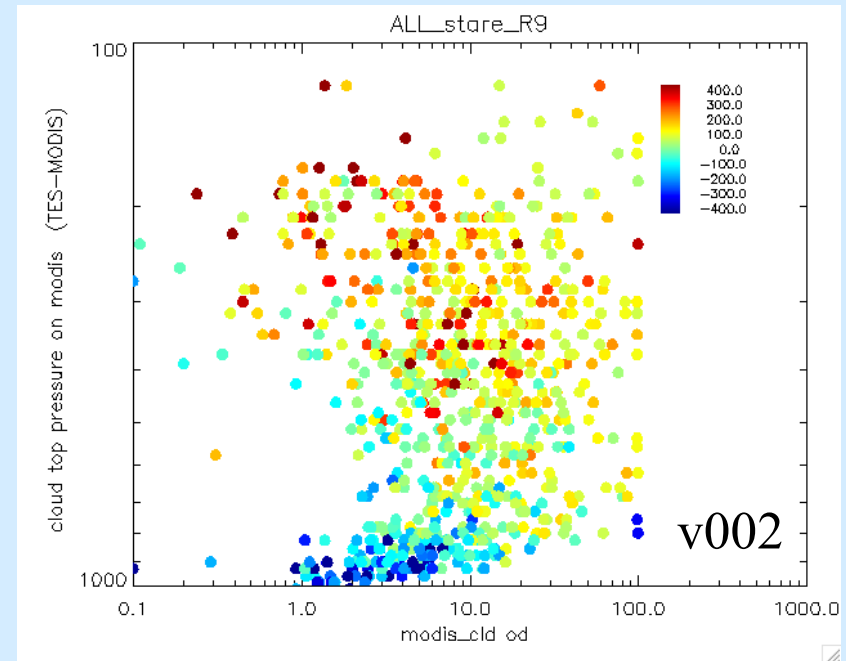
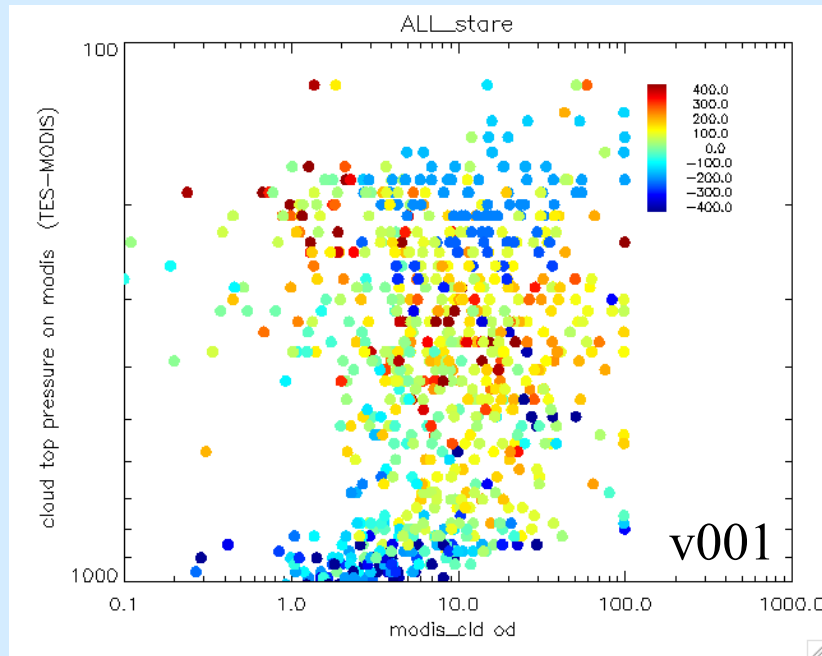
# Improvement of v002



- No longer have tail of -200 mb differences



# Reason for improvement



- Clouds characterized as high clouds are now captured by TES retrieval



# What's ahead?

- Improved initial guess - will place more clouds at very low optical depths
- Limb detection used in R10





# Limb detection



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# Limb Approach

- Forward model calc to predict radiance in window region (use integrated BT10)
- Label pixel as cloudy if measured - model greater than threshold
- Also discard one pixel above cloudy one
- Conservative thresholds developed empirically with AIRS clouds, visible imagery, and set of a few hundred footprints.

